In the session of the international subcommittee on aeronautics, the best methods of carrying on the exploration of the atmosphere with sounding balloons and kites were thoroughly discussed. Its conclusions were adopted by the international committee, which met on the afternoon of September 15, after the close of the congress and held its session in the room at the top of the Eifel Tower. Teisserenc de Bort obtained the best results with lacquered paper balloons of from 50 to 100 cubic meters in volume, and these were recommended by the subcommittee, which also recommended that all the self-registering apparatus carried by balloons and kites should be made according to the model of that made by Richard for use at Trappes.

The subcommittee on clouds listened to an interesting address by Poey on the classification of clouds; the cloud measurements in Russia were treated of by Rykatcheff, and those at Blue Hill by Rotch; an automatic telemeter for the measurement of cloud heights was described by Sprung.

The committee on solar radiation listened to Edelstam explain the construction and use of the new electric compensation pyrheliometer devised by Knut Angström, and the apparatus for the measurement of the general light of the sky devised by Dr. Onimus.

The subcommittee, on the improvement of the telegraph service, contended earnestly for the removal of the three or four hours' difference in European observations, but the difficulties in the way of accomplishing this were so great that it was decided to refer the subject to a committee consisting of official delegates representing the interested states.

Professor Mascart presided over the congress and subsequently over the permanent committee; Hildebrandsson was chosen as secretary of the committee.

The permanent committee adopted the two following resolutions:

1. The directors of meteorological institutions are invited to make observations on the movements of the clouds and, if possible, photogrammetric observations of their altitude and velocity on the days of international simultaneous balloon ascensions, which will be properly announced beforehand, in order that these observations may have the widest extension possible. It is also desirable that such observations shall be made on the day before and the day after the balloon ascensions.

2. The international meteorological committee requests its president, through his government officially, to bring about that the military aeronautic establishments of France and other countries, as well as the central meteorological institutes, be required by their governments to take part in the monthly international scientific balloon voyages. The next session of the international meteorological committee will be held in 1902 in London.

METEOROLOGY AND GEODESY.

The United States Coast and Geodetic Survey has recently published a volume containing Dr. Schott's report on the general results of the Transcontinental Triangulation and the American Arc of the Parallel. In its present shape this work was officially begun by Prof. Benjamin Peirce, the third superintendent of the Survey, while the completion of the work and of the volume marked the last year of the incumbency of Prof. H. S. Pritchett. It is only proper to add that for many years the senior assistant of the Survey, the Nestor and educator of American geodesists, Mr. C. A. Schott, has been guiding the work of the Survey in this direction. There are many matters in which geodesy and meteorology have a common interest, and the Weather Bureau is perhaps equally interested in the proper prosecution of the work of the Coast and Geodetic Survey, the Hydrographic Office of the United States Navy, the topographic and hydrographic work of the United States Geological Survey, and the instrumental work of the proposed Government bureau of standards. In examining this last great volume on triangulation a number of items have attracted our attention which it will be profitable for all to consider who are interested in meteorology.

The general object of geodesy is to determine first the general size and shape of the earth and distribution of the apparent force of gravity, and then their irregular deviations. But these are the very figures that lie at the base of all meteorology. It is true that the meteorologist has provisionally assumed a spherical globe and the distribution of gravity that belongs to a homogeneous ellipsoid of revolution, but the accurate work of the Coast Survey will show us to what extent these assumptions deviate from nature, whence we may judge what effects such deviations will have in meteorology. For instance, in the American Meteorological Journal, May, 1894, Vol. XI, page 1, the Editor has endeavored to show that the observed abnormal variations of gravity along a parallel of latitude from Washington to San Francisco are of the same order of importance as the viscosity or internal friction of the air, consequently the variations in gravity must be considered in any investigation that takes into account viscosity as contributing to the resistance which we call friction. Both must be considered or both neglected together. The most important friction terms in meteorology are those that arise from the resistance of the land as compared with the ocean, or of mountains and waves as compared with smooth surfaces, and an equally important source of resistance, which for brevity the Editor has called convectional friction, arises from the fact that ascending and descending currents, as they intermingle, resist each other's horizontal motion, because one of them, usually the ascending current, has a decidedly slower motion than the other, or perhaps even a movement in the opposite direction. The general rise of the barometer up to its maximum at 10 a. m. seems to be explained by the fact that a part of the greater kinetic energy of the swifter currents that descend to take the place of rising air is transformed into pressure or potential energy, both because its horizontal component must push the lower air along faster than it was previously going, and because its vertical descending component is resisted by the earth. Whenever a rapidly moving fluid gives up a part of its momentum to a more slowly moving fluid or solid an increased elastic pressure is produced within both fluid masses, similar to the resisting pressure at the head of a rapidly moving projectile. For velocities less than that of sound, and for changes of pressure and velocity that are produced almost adiabatically, the new pressure and volume P_1 and V_1 are connected with the initial P_0 and V_0 by the equation

$$P_1 / P_0 = (V_0 / V_1)^{1.407}.$$

The second part of Dr. Schott's report is devoted to the determination of the heights of the stations above mean sea level. The foundation of this work is a continuous line of spirit levels of the highest degree of accuracy, extending from Sandy Hook, N. J., on the Atlantic coast and tidewater on the Gulf coast to the eastern flank of the Rocky Mountains at Colorado Springs, Colo., thence by triangulation westward to the Sierra Nevada, and thence by levels to the Pacific Ocean. The middle portion of this line will eventually be replaced by continuous leveling, a rather tedious operation, over the Rocky Mountain Plateau, but essential in consideration of its practical applications. The results published in Part II deal more directly with the primary triangulation stations whose approximate elevations are needed for the computation of the length of the arc of the parallel. A short table is given showing that the new determinations differ by quantities as large as −355 and +242 feet from the older determinations of altitude. The elevation of the Weather Bureau station on the summit of Pikes Peak is reduced from

14,134 to 14,108 feet, which correction is in fact very moderate and is due largely to errors in the railroad leveling, cumulative from St. Louis, Mo., to Colorado Springs, Colo. The levels and other measurements carried westward from the Atlantic to Mount Corness in California gave its altitude 12,585, while the levels carried eastward from San Francisco Bay at Oakland, Cal., gave 12,556. The discrepancy is small, but its larger part will undoubtedly be removed when the accurate leveling across the Rocky Mountain region is completed. The reduction of Weather Bureau stations to sea level depends almost wholly on altitudes deduced from the innumerable railroad and canal surveys that are spread over the country and every increase in the accuracy of these levelings, or the substitution of the high class work of the Coast Survey is to be welcomed by the meteorologist.

Whenever the Survey substitutes the measurement of vertical angles in place of leveling, as it has done in the case of the long lines of sight from mountain top to mountain top, it has to contend with the problem of the refraction of rays of light passing through the earth's atmosphere. This refraction depends upon the density of the air as a function of moisture, temperature, and pressure. The results of the observations and calculations contained in Part II have, therefore, a profound interest for the meteorologist. He obtains some insight into what is going on at a height of 10,000 or 20,000 feet above sea level, in a region otherwise accessible to him only by kites or balloons. The general changes in the distribution of temperature are suggested by the observed hourly values of the coefficient of refraction, as determined from the elaborate work of the Coast Survey. Observations on the coast of Maine and the coast of California, as well as in the interior of the Rocky Mountain region, lead to several interesting results: the refraction is greater and more irregular during the night hours than during the day; the maximum value is within two or three hours of midnight, and the minimum within two hours of noon; the average of the twenty-four hours is greater the nearer the line of sight is to sea level, or it steadily increases as the height above sea level decreases, except where the temperature is abnormally high or low; the computed refractions are most reliable between the hours 10 a. m. to 5 p. m., but during most of this time the images are faint and unsteady, and observations are difficult. The diurnal range of the refraction is greatest at the low stations; the coefficient of refraction is smaller in proportion as the lines of sight are shorter, probably because the sight-lines then also pass nearer the heated ground where the warm stratum of air is found; when ground is barren and treeless and the climate very dry, and the line of sight passes close to the earth the coefficient is smallest; refraction is larger on the coast as compared with the interior, the average of nineteen sight lines near the coast gave the coefficient $m=0.0854$, whereas lines in the interior, a little farther eastward, gave 0.0751.

As the coefficient of refraction must depend, among other things, upon the horizontal distribution of pressure and temperature, it is important that the geodesist should, in the future, consult the daily maps of isobars and isotherms in order to introduce greater accuracy into these calculations and explain away some of the anomalies that occur. The Weather Bureau station on Mount Tamalpais must be near the geodetic station, whose altitude is given on page 279 as 2,594.3 feet.

The steadiness of an object in the field of view of a telescope depends upon the oscillations or minute variations in the refraction of light at every point of the long line of sight through the atmosphere. When one looks at a star his line of sight penetrates a great distance of very rarefied air, equivalent if the star is in the zenith to about eight miles of air of the standard density at sea level; but when the star is in the horizon, one may be looking through 50 or 100 miles of such air, and the star is seen to be a much distorted disk having the colors of the spectrum, and dancing about in such a fashion as to constitute the worst possible condition for accurate measurements. Now, the lines of sight between mountain tops in the Sierra Nevada and the Rocky Mountains have been in one case as long as 182 miles. At this distance nothing can be seen except the image of the sun reflected from the heliotrope mirror and shining as a dull red or yellow patch through the atmospheric haze. The hours and days on which this image stands steadiest are those selected for geodetic work, they are also those which show when the atmosphere is clear and quiet, or when ascending and descending currents are producing the least disturbance. The observers record that on long east and west lines, when the sun is below the horizon of the observer, it may still be above the horizon of the distant heliotrope mirror, and be thereby observable in his telescope for several minutes after it has entirely set to his own direct observation. The "seeing," that is to say, the steadiness of image is greatest from sunrise to 8 a. m., and from 4:30 p. m. to sunset; the seeing is usually better in the morning than in the evening; on the long lines the minimum refraction of the day occurs late in the afternoon, even after the maximum heat of the day at the earth's surface has passed by.

On these mountain stations meteorological observations are made such as dwellers in the low lands never experience. It would seem almost impossible for the students of meteorology ever to accumulate enough data from these regions to give us a complete survey of the wonders of our atmosphere. We quote the following from page 554, in which assistant W. Eimbeck describes his experience on Rocky Mountain summits in 1885 and 1895:

> It may be remarked that the conditions of the weather on these high mountains could not be called unfavorable during the ordinary field season, which lasts from about the 1st of June to the 1st of November, excepting, however, the period of thunderstorms in midsummer. These thunderstorms, on account of their persistency among the high mountains, have frequently given rise to much suffering, danger, and delay in the progress of the work. They would envelope or hover around the mountains for days in succession, accompanied by the most violent electrical discharges and thunderbolts imaginable. During such times the whole mountain top fairly hummed or hissed by virtue of escaping electricity, and sparks a couple of inches in length could easily be drawn from any exposed insulated object. These storms would usually set in about 11 o'clock in the morning and last till long after sunset. Though no fatality is, fortunately, to be recorded, they proved, nevertheless, the main cause of discomfort and danger to the party exposed to their fury. The highly attenuated state of the atmosphere, the icy blasts during stormy periods, often accompanied by hail and snow, contributed their share to the depressing and dismal feeling during such exposures. The experience of the heliotropers would seem to have been perilous, for three of them were knocked down and rendered partly unconscious, while a tent, several signals, and a theodolite were demolished by lightning. The (so-called) equinoctial snowstorms which annually break over these mountains with surprising regularity were usually borne without concern. They arrive about the beginning of October and, though sometimes severe and followed by intense cold, they seldom caused other than mere temporary interruption in the communication with the camp below.

For further details of similar experiences on the summit of Pikes Peak see the journals of the Weather Bureau observers, as published in full in the volume of observations printed by the astronomical observatory, Harvard College, Cambridge, Mass. As the relative positions and elevations of stations on the summit of Pikes Peak will always be of interest in meteorology, we take the following items from Mr. Tittmann's report on page 570. The old Signal Service station (1), occupied from October, 1873, to September 30, 1888; the new Weather Bureau station (2), occupied from September 8, 1892, to September 30, 1894; the Coast and Geodetic Survey latitude pier (3), and the edge of the bluff

(4) have the following positions relative to the geodetic triangulation station (T) marked by a drill hole in the concrete foundation of the pier on which the theodolite was mounted: The pier is 12.8 feet high; No. (1), or the northwest corner of the old Signal Service building, now used as a stable, is 177.4 feet southeast of the triangulation pier (T); No. (2), or the south chimney of the new Weather Bureau building, is 525.26 feet south, 75° 41′ east of (T); No. (3), the latitude pier, is 18.11 feet north, 88° 41′ west of (T); the nearest point of the bluff is distant about 72 feet north-northwest of (T). Differences in level are not given, but it is stated that the top of the peak is flat and nearly level, is a Government reservation covering many acres, and has easy access by means of the Manitou and Pikes Peak Cog Railway.

The so-called Great Hexagon has for its central point Wheeler Point, Nev., formerly known as Jeff. Davis Peak, in the Snake Range, White Pine County, Nev., latitude 38° 39′ N.; longitude 114° 19′ W. This station was established in 1878. A hexagon of slightly inferior dimensions adjoining it on the west, having Toiyabe Dome as its center. The meteorologist, knowing well the great snowfall and terrible storms of this region, can appreciate the remarks on page 572:

> While engaged upon the work on Wheeler Peak (November 5–23) the party was practically buried in a snow drift 10 and 12 feet deep, the temperature of the air sank to 20° below zero Fahrenheit, and in order that the observations upon distant stations might be continued, deep and broad trenches had to be cut through the snowdrifts in the line of sight. The party suffered much from the intensity of this cold wave. The high snowdrifts which covered the living tents to within a foot or two of the apex saved the party from freezing to death.
>
> At this station the brilliancy of the reflected moonlight suggested to the observer the selenotrope for occasional use at night, and it was experimented with at other stations.

The cold wave here referred to was apparently that which occurred in connection with the area of high pressure No. II, as described in the MONTHLY WEATHER REVIEW for November, 1882. The snowfall for that month was above the normal in the northwestern portion of California. The auroral displays were unusually frequent and brilliant and the accompanying electrical or ground currents on telegraph lines were unprecedented in Europe, as were also the magnetic storms of November 16–23. Auroras were recorded at Salt Lake City, Utah; Los Angeles, Cal.; Yuma, Ariz.; San Diego, Cal.; Galveston, Tex.; Punta Rassa, Fla., and thence northward into Canada, being the most remarkable exhibition on record since 1859.

On pages 733–777 Dr. Schott discusses the effect upon geodetic work of the periodical change in latitude discovered by the astronomer, Dr. S. C. Chandler, At the present time these variations are less than one second of arc and are so nearly periodic that we are not yet able to speak of an appreciable secular change in latitude. But there can be no assurance that the rise and fall of continents and ocean beds and the consequent shifting of ocean water may not in the past have caused appreciable secular changes in the position of the pole relative to the earth. Of course, such changes would necessarily bring such a strain upon the earth's crust that it would yield or bend and crack, or rather, the trends and faults would cause the axis and latitudes to change. The earth taken as a whole, when we consider the geological faults that exist everywhere, must be treated as a viscous body continually yielding to strains due to luni-solar tides, the gravitation of its mass, the weight of the ocean, the atmosphere, the great lakes, and the great glaciers. It is rigid as steel to the strains of short periods, but plastic under long-continued strains. The yielding process is so slow, the faults proceed step by step so gradually, that great changes in surface features require geological ages for their evolution, while during this whole long time the general figure of the earth may remain the same as at the present day, i. e., the Clarke spheroid. It is certainly very interesting to learn, from page 871, that a combination of all the American measures shows that Clarke's spheroid of 1866, whose polar radius is 6,356,584 meters and equatorial radius is 6,378,206 meters represents the shape of the western continent quite accurately, and will continue to be adopted by the Survey until the measure of a meridional arc enables us to adopt definitely something appreciably better.

PERIODICITY IN METEOROLOGY.

The Weather Bureau has lately received many communications relative to supposed periodic or other systematic changes in the weather, depending upon variations in the Gulf Stream, variations in the sun spots, earthquakes, changes in terrestrial magnetism, and other more or less elusive subjects.

These communications must be taken as simply an evidence of the great importance of the weather to the human race. All wish to know about the laws that govern the changes in climate in order the better to arrange their business affairs. One correspondent asks whether the Gulf Stream has not undergone such changes as to prevent the recurrence of the damaging frosts and freezes that have done so much injury in Florida during the past six or eight years. If we were able to assure our correspondents that we understand all the laws that govern frosts and storms, they might indeed lay aside the ordinary precautions against disaster and proceed calmly in the assurance that such troubles are not now imminent; but it will not do for any one to discard protection against injurious conditions. If any periodicities have been discovered they are such as to be of very little importance in comparison with the ordinary irregularities of the weather. Thus, Brückner finds a period of about thirty-five years in the annual average temperatures, but the extent of this regular period is about half a degree Fahrenheit, while the irregularities in the annual mean temperatures amount to five or ten degrees. Köppen, by examining the mean annual temperatures for the world, found that in equatorial regions there was an amplitude of about one degree Fahrenheit, corresponding with the variations of the sun spots; but in polar latitudes this disappears, and the irregular nonperiodic changes become much larger. Quite lately, Lockyer, in a joint paper with his son, showed that possibly there may be a connection between the condition of the solar atmosphere, as shown by the widening of the lines of the solar spectrum, and the rainfall, temperature, or other meteorological phenomenon.

Now, all these and many other investigations go to confirm us in our belief that all the phenomena of nature, whether solar or terrestrial, physical or biological, are so intimately connected that through any one of them we may get some idea of what is going on in the other department, but they do not in the least justify us in believing that the principal fluctuations in one can be ascertained by studying those of another. To those who have studied the atmosphere it is plain enough that it contains within itself the elements and forces that are able to bring about all the great irregularities that affect mankind. Even the great changes of climate that appear to have occurred during geological ages can probably be explained by the study of the atmosphere and the earth, without having recourse to the stars, sun spots, meteors, magnetism, electricity, or Fourier's hypothesis of warm and cold regions in the space through which the earth is supposed to travel.